SPECIAL REPORT THREE

ABRASION RESISTANT WINDSHIELDS FOR HELICOPTERS LITERATURE SEARCH AND INVESTIGATION OF RECENT CONTRACTOR ACTIVITY

OCTOBER 1966

PLASTEC

PLASTICS TECHNICAL EVALUATION CENTER

PICATINNY ARSENAL
DOVER, NEW JERSEY

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ABRASION RESISTANT WINDSHIELDS FOR HELICOPTERS

LITERATURE SEARCH AND INVESTIGATION OF RECENT CONTRACTOR ACTIVITY

by

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For: U. S. Army Materiel Command

PLASTICS TECHNICAL EVALUATION CENTER

Picatinny Arsenal Dover, New Jersey

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1. OBJECT OF SEARCH

Helicopters generally have stretched-acrylic windshields which are said to scratch easily in service due to wiper operation or impingement of sand or stones. Operation of the wiper without the use of a lubricant (such as water) is particularly damaging. Also, while in flight, any impingement of such objects as birds or bullets may result in catastrophic failure.

The object of this search is to make a literature survey, and to contact several leading commercial manufacturers in order to obtain current information on abrasion-resistant windshields.

2. SUMMARY OF SEARCH

The information search was confined mainly to the following concepts:

(a) Use of an abrasion resistant plastic, or a plastic with a highly abrasion resistant coating.

(b) Use of a glass/plastic or glass/glass laminate. It is generally agreed that glass is many more times abrasion resistant than conventional plastics.

(c) Use of a special wiper, or a chemical cleaner (no wiper blade).

(d) Methods for buffing and polishing scratched windshields.

The details of the survey are listed in Part 4. It is apparent that the trend is toward the development of glass/plastic composites for aircraft windshields. The advantages over an all-plastic windshield would be (a) improved abrasion resistance, (b) less deflection, and (c) the use of more efficient conductive coatings for de-icing. Also, there exists a need for high temperature resistant windshields for supersonic aircraft.

There is general agreement by the persons contacted that the best plastic is greatly inferior to glass for scratch resistance. Certain plastics such as CR-39 are said to be more scratch resistant than the conventional acrylic sheet, but are vastly inferior to glass. However, all four suppliers contacted (Sierracin, Swedlow, Goodyear-Aerospace, and Pittsburgh Plate) mentioned that their particular glass/plastic windshields were presently considered to be experimental. Failures such as unexplained cracking of the glass windshield after installation and disintegration of the glass due to impingement of stones have occurred. These failures may be due to the difference in expansion or contraction between the glass and plastic, poor properties of the interlayer, strains in the glass, incorrect stiffness of the glass, or lack of good processing quality controls.

It appears that Corning Glass is a prime supplier of tempered glass for these projects, and they are fully aware of the failures. They have recently made another trial shipment of an improved glass.

It is apparent that certain projects are in process to produce a superior helicopter windshield, but further investigation or experimentation may be required to obtain conclusive data.

3. SOURCES OF INFORMATION

The following government agencies and contractors were searched or contacted by telephone for general information:

(a) PLASTEC

(b) Wright-Patterson Air Force Base

(c) Naval Air Material Center (AML), Philadelphia

(d) Natick Laboratories

(e) Redstone Arsenal

(f) E. I. duPont de Nemours and Co., New York

(g) Corning Glass Works, Corning

(h) Sierracin Corporation, Sylmar, Calif

(i) Swedlow, Inc., Garden Grove, Calif

(j) Goodyear Aerospace, Akron

(k) Pittsburgh Plate Glass Co., Pittsburgh

4. INFORMATION AND REFERENCES

(a) PLASTEC

PLASTEC Report 9 covers the subject of reduction of reflectivity from transparent materials (plastic helicopter canopies), as obtained by applied coatings. This report does not mention scratch resistance, but does contain certain references on various types of coatings (Incl 1).

PLASTEC accession No. 2005 is a report by the Naval Air Material Center (AML), Philadelphia, and covers a laminate consisting of a layer of cast CR-39 (diethylene glycol bisallycarbonate) and a layer of hot-stretched acrylic sheet. Inclosure 2 is an abstract of this report.

(b) NAVAL AIR MATERIAL CENTER (AML), PHILADELPHIA

Mr. Thomas R. Davis, Jr., and Mr. Richel of NAMC were solicited for more recent information on their CR-39/acrylic project. No

additional work has been done since the 1959 report (Incl 2). No complete evaluation of the test samples is available from NAMC, since their main interest was to test the interlayer bond at room temperature. This is said to have been found satisfactory. Mr. Davis stated that it was necessary to abrade the stretched acrylic in order to obtain a good bond with the CR-39.

(c) WRIGHT-PATTERSON AFB, AFML

Mr. Robert Whitman apparently was very familiar with the activity in this area. There is no activity at WPAFB on coatings to improve scratch resistance, and no contracts have been granted to commercial firms because methods to date have not appeared to be feasible. He mentioned that encouraging results were being obtained by the use of glass/plastic laminates, with glass furnished by the Corning Glass Works. Corning has developed glass made by the Chemcor process, which is chemically strengthened.

One of the defects found with glass/plastic laminates is failure due to the difference in thermal expansion of the composite material. Mr. Whitman suggested that we also contact the Pittsburgh Plate Glass Company for additional data. Inclosure 3 is a progress report of the development program for a high temperature aircraft windshield under AF contract to Corning Glass Works. Laminated panels of glass gave unsatisfactory bird impact protection.

(d) NATICK LABORATORIES, NATICK

Mr. Alesi was contacted because PLASTEC had been informed that work was in progress at Natick on transparent armor. The activity appears to be mostly on glass/plastic composites, and some work is being done on plastic specimens.

The main advantage of an all-plastic panel is the reduction in weight. No work is being done to evaluate the abrasion resistance of windshields. However, it was stated that their composites should have the necessary transparency for windshields. Mr. Alesi stated that he thought CR-39 was probably a good abrasive resistant thermoset plastic, but obviously inferior to glass.

(e) REDSTONE ARSENAL

Mr. Ed Verchot, Army Missile Command had requested information from PLASTEC on the subject in May 1965. At that time his interest in windshields was associated with the use of certain auxiliary equipment. The helicopter windshield wiper was sometimes operated in an emergency to remove dirt (without the use of water), and this resulted in severe abrasion of the Plexiglas-55 on the Bell Helicopter UH-1. Verchot suggested the use of a water spray device, subsequently, work on this problem was dropped at Redstone, and Bell Helicopter may be working on this problem. Bell Helicopter was not contacted by PLASTEC. Inclosure 4 is a copy of PLASTEC's report to Redstone in 1965.

(f) E.I.DUPONT DE NEMOURS & COMPANY, INC., NEW YORK

Dr. Kuettel was contacted regarding an old duPont process devised 10 to 13 years ago for coating acrylic sheet to improve abrasion resistance. He indicated that the process produced a surface hardness which was inferior to CR-39. Also, only flat sheets could be coated, and if formed under tension, they would craze or crack due to a chemical change in the coating. He also stated that it would be very difficult for him to obtain data on this process, and he recommended investigation of CR-39 as made by several companies. Inclosure 5 contains duPont literature relating to acrylics, including methods for cleaning and polishing scratched surfaces.

(g) CORNING GLASS WORKS, CORNING, NEW YORK

According to Mr. A. F. Shoemaker, Advanced Products Division, Corning is actively engaged in the development of a chemically strengthened glass for various contracts concerned with producing a glass/plastic windshield. The composites under consideration are glass, a polyvinyl butyral (PVB) interlayer (or a castable silicone or epoxy interlayer), and an inner sheet of plastic. It has been ascertained that different types of material cause different strains. Corning is apparently working with various commercial companies on this project, such as Sierracin and Goodyear. Work is still considered to be in the experimental phase since previous prototypes have failed in service. The glass has disintegrated into small pieces, and new windshields have recently been shipped (for the Chinook) which should show better performance. These should break into larger pieces (if failure should occur due to impact or other causes). It was stated that the DC-8 has an all-glass windshield with a relatively thin outboard glass layer. Since a helicopter usually requires a windshield which has a pronounced spherical curvature, the method of making such a contour in glass requires more technical knowhow and production control.

(h) SIERRACIN CORPORATION, SYLMAR, CALIFORNIA

In order to update the previous information received at PLASTEC from Sierrain, Mr. J. Bronner was contacted. He stated that two glass/plastic windshields were tested on Vertol CH 47 helicopters at Fort Rucker, Alabama, and these windshields broke when struck by a rock. Corning is now supplying additional windshields having a different type of glass. Mr. Bronner stated that to his knowledge, no hard coatings for plastics are presently available, and they consider their type SIERRACIN 900 plastic to be superior to Plexiglas 55. A silicone type interlayer is feasible, but may be degraded by UV. Inclosure 6 contains copies of a letter and literature supplied by Sierracin.

(i) SWEDLOW, INC., GARDEN GROVE, CALIFORNIA

Mr. Jim Gregg was also contacted, to update the previous information received at PLASTEC. Swedlow is also working on a formed,

tempered glass/acrylic composite, but no service tests have been conducted to date. They believe that CR-39 should be better than acrylic, except that a report has been received that, in one windshield installation, CR-39 has fractured. Boeing and Lockheed are said to be developing a chemical type rain removal system whereby the surface rain is changed to droplets. Pratt and Whitney is said to have a silicone wiper blade, and there is said to be a European patent on an air jet removal system. Inclosure 7 contains copies of literature supplied by Swedlow.

(j) GOODYEAR AEROSPACE, AKRON, OHIO

Mr. Don Cully (project engineer-windshields) stated that Goodyear was working on a glass/plastic windshield using Corning chemically strengthened glass. The difference in expansion and contraction of the layers is admitted to be a major problem. Goodyear claims they have developed a good interlayer; however, certain test windshields made for a helicopter have cracked after installation, during flight or on standby. This failure may have been due to the presence of internal strains. A sample of a glass/plastic laminate (about 1 foot square) is being forwarded to PLASTEC, and will be turned over to the PP Laboratory at Picatinny Arsenal. Sikorsky is said to be evaluating the Goodyear glass/plastic composite windshield. Goodyear considers glass to be best for abrasion resistance, but they are also trying to improve the abrasion resistance of CR-39 and acrylic.

(k) PITTSBURGH PLATE GLASS COMPANY, PITTSBURGH

Mr. A. Johnson stated that PPG was also working on a glass/plastic composite windshield for helicopters. Apparently, there are different methods for shaping glass; that is, cylindrical, conical, and spherical. The spherical shape, generally used for helicopter windshields, is considered to be the most difficult to fabricate. They do not as yet claim to have made an acceptable glass/plastic windshield, and one of the problems is to find a way to distribute the internal stresses. He stated that a new helicopter being made by Lockheed ("armed platform") is supposed to have a composite using a thin glass layer which is not bullet proof. Also, they are considering working on a polycarbonate windshield because of the extreme toughness of this material. Perhaps a coating could be developed over the polycarbonate to increase its solvent resistance against certain fuels. They are also experimenting with both stretched and unstretched acrylics. The F-111 variable wing aircraft (General Dynamics) is said to have a curved laminate chemically tempered glass windshield (Pittsburgh Plate Glass - Herculite II).

5. REMARKS

A DDC search has been ordered, and other sources of information are being explored such as the "Conference on Transparent Materials for Aerospace Enclosures" cosponsored by the U.S. Air Force and the University of Dayton, 9 December 1964.

It is felt that the information presented in this report is indicative of the state-of-the-art and the problems associated with the abrasion of plastic windshields.

6. INCLOSURES

NOTICE The "Inclosures" are not reproduced in this special' report. Items 2, 3, 5 and 6 may be obtained by contacting the original source. Inquiries as to items 1, 4 and 7 should be addressed to PLASTEC.

1. Beach, N. E. REDUCTION OF REFLECTIVITY FROM TRANSPARENT MATERIALS: A MEMORANDUM IN EVALUATION OF TECHNIQUES APPLICABLE TO PLASTIC HELICOPTER CANOPIES. PLASTEC Report 9 Plastics Technical Evaluation Center, July 1962.

2. Davis, T. R., JR., and E. K. Rishel PREPARATION OF COMPOSITE TRANSPARENT PLASTIC SPECIMENS. Report NAMC AML AE 1086, Naval Air Material Center, 2 March 1959.

3. Corning Glass Works. Contract AF 33(657)-8922, "High Temperature aircraft windshield development program." L. E. Stamets, project engineer. Project 7-654a, May 1962 to February 1966. In ABSTRACTS OF ACTIVE CONTRACTS, Air Force Materials Laboratory, March 1966.

4. Baldanza, N. T. "Request for information on scratch resistance of aircraft windshields." Inquiry number 65-2-15b, May 1965, Plastics Technical Evaluation Center. (For Ed Verchot, AMSMI-RSM)

5. E. I. duPont de Nemours and Company. DU PONT LUCITE ACRYLIC RESIN, trade literature, unnumbered, undated.

6. The Sierracin Corporation. Personal communication, 26 May 1965, from Jerry Bronner. Submitting the following:
Sierracin Engineering Memo EM-61-115, "Structural properties of Sierracin 900."

   STATUS OF PROGRAM TO DEVELOP COMPOSITE WINDSHIELDS UTILIZING PLASTICS AND CHEMICALLY STRENGTHENED GLASS, by Keith Gunnar, 9 December 1964.

   INTERLAYERS AND LAMINATING, by George L. Wiser, 9 December 1964.

   Copies, Sierracin open literature articles on windshields.

7. Swedlow, Inc. Personal communication, 24 May 1965, from W. O. Pick, submitting material on "Aircraft Transparencies."

7. SUPPLEMENTAL REFERENCES

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"Transparent plastics open new windows on products," in PRODUCT ENGINEERING, 24 October 1966.

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"Water-repellent coating keeps windshields clear," in MACHINE DESIGN, 27 October 1966.

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"Plastic glazing for high-speed aircraft," in MODERN PLASTICS, October 1959.

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ABSTRACTS OF MATERIAL EVALUATION PROGRAMS CONDUCTED AT CHANCE VOUGHT CORPORATION, CVC Report No. 2-53420, by J. J. Peterson, 28 February 1962.

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Muller, Thomas H. Col

Letter to Mr. Denton Anderson (Rowland Products, Inc.) from Office of the Chief of Research and Development, 8 October 1965.

Narmco Research and Development

F-111 WINDSHIELD AND CANOPY PROTOTYPE DEVELOPMENT PROGRAM, Part A, Phase I, NR&D Project 437-001, Corning Glass Works Order CO 63-105; prepared by R. Kantner, 11 June 1963.

Pittsburgh Plate Glass Company

CR-39, AN OUTSTANDING OPTICAL PLASTIC FOR CRITICAL ENGINEERING APPLICATIONS. Trade literature, unnumbered, undated.

Powers, W. J.

Report of telephone conversation with Dr. Peter Kosting, U. S. Army Materiel Command, 13 October 1966.